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Developing Guidance for Implementing Border Carbon Adjustments: Lessons, Cautions, and Research Needs from the Literature

Aaron Cosbey*, Susanne Droege[†], Carolyn Fischer[‡], and Clayton Munnings[§]

Introduction

Economists have long advocated carbon pricing as the most comprehensive and cost-effective way to reduce global carbon¹ emissions (e.g., [Stern and Stiglitz 2017](#)). However, lacking a globally coordinated effort, many individual jurisdictions—including countries, provinces, states, and cities—have unilaterally established carbon prices reflecting their individual capacities and policy contexts. Currently about 50 different initiatives worldwide collectively price roughly 15 percent of annual global greenhouse gas (GHG) emissions ([World Bank and Ecofys 2018](#)). Moreover, with the adoption of nationally determined contributions (NDCs) by parties to the United Nations Framework Convention on Climate Change (UNFCCC) and the 2016 Paris Agreement, international negotiations have shifted more towards facilitating country-level efforts and away from prescriptive targets and mechanisms that could result in a *global* carbon price ([van Asselt and Bobber 2016](#)).

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¹We use “carbon” as convenient shorthand for carbon dioxide (CO₂).

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The current landscape of divergent carbon prices with limited geographic coverage allows scope for international trade to undermine the effectiveness of these carbon pricing regimes through carbon leakage,² adverse competitiveness impacts, and a lack of political support for strong action (Droege et al. 2009). Thus jurisdictions that do price carbon frequently attach measures to level the international playing field—for example, by offering free allocation of emissions allowances to industries at risk of leakage.

Border carbon adjustment (BCA) is another tool for addressing carbon leakage. With BCA, a country uses trade measures to put products from foreign producers who operate without a carbon price on an even footing with products from domestic producers who do face a carbon price. The rationale for BCA is to ensure that consumers face consistent prices regarding the carbon content of the products they buy (Droege 2011). The idea is to levy a charge on imported goods that is equivalent to the carbon payment that would have been made had the goods been produced domestically. When combined with a domestic carbon tax, BCA resembles the treatment of common consumption taxes, notably value-added taxes, which apply only to domestically consumed goods. Such a BCA might also offer relief to exported goods by rebating the associated domestic carbon payments, thus ensuring that domestic exporters are not disadvantaged in international markets vis-à-vis competitors in jurisdictions without carbon pricing. When combined instead with an emissions trading system (ETS), a BCA could require domestic importers or foreign exporters of goods to buy emission permits based on the amount of carbon emitted during production of the goods, imposing a requirement analogous to that faced by domestic producers.

Although BCA is a tool that has largely remained inside the toolbox,³ it continues to be proposed. For example, BCA was featured in (unsuccessful) U.S. climate legislation (e.g., the American Clean Energy and Security Act of 2010, the American Opportunity Carbon Fee Act of 2014), and BCA is a key component of the U.S. Climate Leadership Council's current proposal for a carbon taxation system (Baker et al. 2017). In the European Union (EU), the attempted regulation of aviation-sector emissions resembled BCA, and a BCA for cement imports was proposed for the EU ETS.⁴ Moreover, with the election of U.S. President Donald Trump, and his stated intent to withdraw from the Paris Agreement, U.S. trading partners have begun openly discussing carbon tariffs; for example, Mexico has mentioned BCA in its NDCs (Davenport 2016). Finally, prominent economists and political scientists have proposed using trade measures to support carbon pricing “climate clubs” (e.g., Victor 2011, 245; Gollier and Tirole 2015; Nordhaus 2015).

While the concept of BCA is straightforward and intuitively appealing—that is, shifting toward consumption-based carbon pricing—its design and implementation is quite challenging in practice. In particular, a policymaker crafting BCA provisions must make numerous, complicated regulatory choices, including the BCA's scope of applicability (i.e., which policies, goods, sectors, countries), the methodology for assessing the carbon content of

²We define carbon leakage as occurring when the implementation of a climate policy (particularly carbon pricing) in one jurisdiction leads to increased emissions in other jurisdictions. It is distinct from the broader concept of global trade in embodied carbon, where carbon-intensive production tends to shift toward developing countries and return as imports to industrialized countries (Peters et al. 2011).

³A form of BCA is currently playing a role in California's ETS, designed to prevent the shift of electricity production to dirtier out-of-state generators.

⁴The European Parliament rejected this amendment in February 2017.

products, the type and price of the adjustment, scenarios requiring modification, and how the resulting revenues will be used. Each of these choices has economic and environmental implications that influence the effectiveness of the BCA, as well as nuanced technical, legal, and political consequences that must also be considered.

This article reviews the economic and legal literature on BCA and, based on this review, distills guidance for the design and implementation of effective and legally sound BCA. The next two sections present background on the economics of carbon leakage and the relevant legal context. Then we provide guidance regarding the key design choices for BCA and discuss remaining gaps in the literature concerning these choices. The final section summarizes and suggests future research.

The Economics of Carbon Leakage

Policy-induced carbon leakage concerns policymakers because it undermines the objective of a domestic climate policy—reducing global GHG emissions—and raises the level of effort and costs of achieving the intended abatement goal. The economics literature has identified several channels for carbon leakage, attempted to quantify leakage rates, and examined the potential for BCA to reduce leakage.

Channels for Leakage

The literature identifies at least four channels through which carbon can leak (Droege et al. 2009). Understanding each channel is important for both interpreting empirical studies of leakage (which do not always capture all channels) and evaluating antileakage policies.

The first and most politically sensitive channel—and the one that is targeted by BCA—is the *competitiveness channel*. Carbon pricing raises the costs of producing goods in the implementing jurisdiction, which potentially puts foreign goods at a comparative advantage. Consumers and producers may respond by substituting away from domestic products toward cheaper foreign ones, causing both a loss of market share and lower profits for domestic producers. As a result, production and emissions increase outside the implementing jurisdiction (Fischer and Fox 2012b). In the longer run, investment may also shift toward foreign production, due to differences in the returns on capital associated with carbon pricing—and possibly leading to the relocation of existing or planned production capacity.

Second is the *energy market channel*. Most carbon emissions stem from the burning of fossil fuels. Reducing demand for fossil fuels in regulated regions drives down the world price of fossil fuels, which in turn increases fuel consumption and carbon emissions in nonregulated parts of the world. This channel is often found to be both the main driver of carbon leakage overall (e.g., Branger and Quirion 2014a) and the most difficult to address without global carbon pricing.

The *income channel* recognizes that the cost of abatement measures and the change in relative prices triggered by the introduction of carbon pricing can cause significant changes in the terms of trade, which in turn affects global income distribution. The resulting changes in consumption patterns could, in theory, raise or lower foreign emissions (Karp 2013). Similar indirect effects on output can occur if changes in input demand in the regulated region drive up wages and the prices of cleaner inputs, potentially lowering the nonregulated region's

output and emissions (Baylis, Fullerton, and Karney 2014). By their nature, however, income channel effects are secondary and unlikely to offset much of the direct effects of the competitiveness and energy channels (Carbone 2013; Winchester and Rausch 2013).

The *technology spillovers channel* also raises the possibility of negative leakage (i.e., lower foreign emissions). In this case, carbon pricing in the implementing jurisdiction induces innovation in “green” technologies, which “spill over” to nonregulated regions and induce emissions reductions (Barker et al. 2007; Gerlagh and Kuik 2014; Fischer 2016). The least is known about this channel because technology spillovers play out in the longer term and good empirical evidence for predicting them is lacking.

Quantifying leakage

To assess the scope of the carbon leakage problem, we review the literature on leakage rates—measured as the increase in foreign emissions as a share of reductions in domestic emissions. Many studies rely on *ex ante* numerical simulations using computable general equilibrium (CGE) models, which capture interindustry and international relationships over the medium to long run (Carbone and Rivers 2017). In the absence of antileakage policies, central estimates of leakage rates for industrialized countries fall between 5 percent and 30 percent (Böhringer, Balestreri and Rutherford 2012). Results indicate that only a small number of industries have high leakage rates under economy-wide carbon pricing (e.g., Morgenstern et al. 2004; Fischer and Fox 2012b).

Partial equilibrium (PE) models have been used extensively to examine “energy-intensive and trade-exposed” (EITE) industries, including cement, aluminum, and steel and iron production. These studies estimate leakage rates that range from 8 percent (Demailly and Quirion 2008) to 90 percent (Chen 2009) in scenarios excluding measures to mitigate leakage. In the EU, leakage rate predictions for EITE sectors are in the middle of the range—20–73 percent for the cement sector (Demailly and Quirion 2006, 2008; Ponssard and Walker 2008)—and approximately 30 percent and 50 percent, respectively, for the aluminum and steel sectors (Demailly and Quirion 2008).

A smaller literature has drawn on recent experience to extrapolate leakage effects from carbon pricing. Dechezlepretre and Sato (2017) recently reviewed these *ex post* studies. They found that competitiveness effects of environmental regulations and energy price differentials can be documented, but the effects tend to be small relative to those of other determinants of trade (e.g., infrastructure, geography, availability of raw materials, and skilled labor) and are often mitigated by innovation activity. A challenge for *ex post* evaluations is the lack of carbon pricing at levels (or timescales) that would actually induce leakage. The gaps between *ex ante* and *ex post* leakage estimates, as well as between the perceptions and estimates of leakage risk, suggest a need for further research.

Effectiveness of BCA in Reducing Carbon Leakage

BCA cannot completely eliminate leakage, foremost because it only addresses the competitiveness channel. Furthermore, economic theory suggests that tariffs alter the terms of trade, which can undo their effects on foreign emissions (Markusen 1975). However, while simple two-sector, two-country models indicate limitations to the effectiveness of BCA

(e.g., Jakob, Marschinski, and Hübler 2013), detailed numerical analyses using multisector, multiregion models consistently find significant potential for BCA to reduce leakage rates.

For example, in a summary of the results from twelve CGE models,⁵ Böhringer, Balistreri, and Rutherford (2012) find that BCA reduces leakage rates by about one-third (from a mean of 12 percent to 8 percent). One model incorporating the competitive selection of heterogeneous firms (following the new trade theory of Melitz [2003]) finds substantially higher leakage rates and greater effectiveness of BCA (Balistreri and Rutherford 2012). Branger and Quirion (2014b) performed a meta-analysis of 35 ex ante studies and found that BCA reduced estimated leakage rates from a mean of 14 percent to 8 percent. They also found that extending the BCA to all sectors (rather than applying it to EITE sectors only) and border-adjusting exports further reduce leakage.

By passing carbon costs through to consumers, BCA tends to be more cost effective than other unilateral options such as targeting vulnerable EITE sectors with exemptions (Böhringer, Carbone, and Rutherford 2012) or output-based allocations (Fischer and Fox 2012b). However, BCA is not a panacea for EITE industries, because they may use carbon-intensive intermediate inputs from nonregulated regions or face weaker domestic demand from rising prices (Böhringer, Carbone, and Rutherford 2018; Burniaux, Chateau, and Duval 2013). Furthermore, by changing the terms of trade, BCA shifts more of the climate policy burden toward developing countries (Böhringer, Fischer, and Rosendahl 2010). These questions concerning effectiveness and distributional effects are not only of economic consequence, they are also relevant for the legality of BCA.

The Legal Context

Any discussion of best practices for BCA must also consider international law. The principle of common but differentiated responsibilities (CBDR) and respective capabilities, under which stronger actions are expected from developed than developing countries, is crucial to UNFCCC negotiations. Moreover, World Trade Organization (WTO) agreements impose legal constraints on trade measures. We next explore key legal concepts and commitments as they relate to BCA design.

BCA as a Border Tax Adjustment

If BCA is implemented in conjunction with a carbon tax, then under trade law, it would be considered a border tax adjustment (BTA), which is explicitly allowed if it meets certain criteria. First among these is passing the *like products* test, which is about determining the nature and extent of the competitive relationship between the imported and domestic products.⁶ The determination of likeness takes into account (inter alia) the physical properties of the two goods, the tariff classifications of the two goods, the goods' end uses, and consumer preferences toward the goods.⁷ BTA is allowed for like goods, but it must also meet General Agreement on Tariffs and Trade (GATT) requirements concerning

⁵The model comparison exercise was organized by the Stanford Energy Modeling Forum (EMF).

⁶See GATT Article III and *US – Clove Cigarettes* (AB), paras. 103–120.

⁷See *EU – Asbestos* (AB), para. 101.

national treatment.⁸ This first principle of nondiscrimination effectively mandates that any adjustments to imported goods cannot result in treatment that is less favorable than the treatment of like goods produced domestically. Would penalizing carbon-intensive imports more heavily than clean domestic goods violate national treatment? WTO case law appears to suggest that such differential treatment would be legal if based purely on carbon content rather than the goods' country of origin (Pauwelyn 2013); however, there is no consensus on this issue (Holzer 2014; Trachtman 2017). A BCA regime may then be judged to treat imported goods less favorably in order to protect domestic producers, in which case its legality would rest on meeting GATT's General Exceptions (discussed later).

BCA as Regulation

The law generally treats regulations differently than taxes, even if both amount to emissions prices. If the BCA is implemented alongside an ETS (e.g., requiring that importers purchase allowances equivalent to what the ETS requires of domestic producers), it would almost certainly be covered as a form of domestic regulation under GATT,⁹ which requires that the imported product receive regulatory treatment no less favorable than the like domestic product. This means, for example, that foreign producers may not be required to have emissions third-party verified when domestic producers do not, and that baseline emissions for imports may not be more onerous than for like domestic goods. A BCA found to discriminate against imported products could only be implemented if it meets the GATT exceptions requirements.

Most-Favored Nation Treatment

With either a carbon tax or an ETS, BCA must also adhere to the *most-favored nation* (MFN) principle,¹⁰ which prohibits discrimination between like products on the basis of the country of origin. A BCA may conflict with this second GATT principle of nondiscrimination if it calls for special treatment for some countries (e.g., less developed countries [LDCs], signatories to a certain treaty). Similarly, differences in the assumed levels of embodied carbon in imports that are based on variables specific to the country of export—as opposed to the individual producer—could also be seen as violating MFN (Pauwelyn 2013). Some forms of discrimination that favor LDCs are allowed under the WTO's *Enabling Clause*,¹¹ but only those explicitly aimed at aiding development in the beneficiary countries, which is not the mandate of BCA.

GATT Exceptions and Chapeau

Violations of the GATT principles of nondiscrimination are permitted under exceptional circumstances laid out in Article XX; its clauses may pose the ultimate legal test for BCA. The two most relevant circumstances are that the measure is necessary to protect human, animal

⁸See GATT Article III:2.

⁹Specifically, it would be covered under GATT Article III:4.

¹⁰This is GATT Article I, which complements GATT Article III.

¹¹The Enabling Clause (1979). *Differential and more favorable treatment reciprocity and fuller participation of developing countries*, Decision of the GATT Contracting Parties of November 28 (L/4903), para. 3(a).

or plant life or health, or that it relates to the conservation of exhaustible natural resources (if such measures are applied in conjunction with restrictions on domestic production or consumption).¹² Analysts generally believe that it is easier to pass the latter test, given the need to prove necessity in the former (de Cendra 2006; Horn and Mavroidis 2011). In fact, past dispute panels have defined clean air as an exhaustible natural resource and interpreted “relates to” as implying a reasonable relationship or connection between the measure and the conservation of the resource in question (i.e., between the means and the ends).¹³ According to these interpretations, any BCA must demonstrate that it actually addresses climate change—that the means (the BCA) has a close connection to the ends (mitigating carbon emissions). Thus any different treatment for different countries must be justified with a strong environmental rationale.

If a BCA regime is deemed eligible for an exemption, then it must also conform to the GATT’s *chapeau* requirement,¹⁴ which requires that any breach of GATT obligations be justified by the desired end—in this case, addressing climate change by preventing carbon leakage—and that implementation of the measure—in this case, the BCA—is neither arbitrary nor carried out in a way that is aimed at protecting domestic interests vis-à-vis foreign producers.¹⁵ Case law also indicates that a BCA may be difficult to implement unless good faith attempts to reach a multilateral solution to the problem of carbon leakage have already been made.¹⁶

Subsidies and Countervailing Measures

The WTO Agreement on Subsidies and Countervailing Measures (SCM Agreement) disciplines the use of subsidies to domestic producers and delineates permissible responses to imports that are subsidized in violation of the agreement. The SCM Agreement prohibits any subsidies that are conditioned on the export of goods,¹⁷ and therefore may limit the ability to apply BCA to exports (de Cendra 2006). Because the SCM Agreement is separate from the GATT, the General Exceptions do not apply, which means prohibited subsidies cannot be justified using the environmental protection rationale.

Although the GATT allows BTA for both imports and exports, meaning that value-added tax adjustments are not considered subsidies, the treatment of an export adjustment of a carbon tax remains an open legal question. The answer depends on whether a carbon tax is considered to be a direct tax (on a factor of production, like payroll taxes) or an indirect tax (on consumption, like a VAT). Following the GATT Working Party on Border Adjustment

¹²These refer to GATT Article XX, subparagraphs (b) and (g), respectively. The third test is that the measure conform to the chapeau of Article XX, which we discuss later.

¹³See *US – Gasoline* (para. 6.37) and *US – Shrimp* (AB) (para. 141), respectively.

¹⁴The introductory clause of Article XX.

¹⁵In *Brazil – Retreaded Tyres*, a Brazilian import ban was ruled unjustifiable discrimination because it contained an exception that allowed significant imports of the environmentally problematic used tires. Similarly, in *EU Seals*, the EU provided an exception to its import ban on seal products that was aimed at benefiting indigenous hunters rather than justifying the ban based on the legitimate objective of public morals (Article XX(a)).

¹⁶In *US – Shrimp*, the United States did not attempt to negotiate turtle conservation agreements with other countries before imposing the import ban, even though protection of a migratory species is inherently an international challenge that demands international cooperation.

¹⁷See SCM Agreement Article 3.1(a).

(1970) guidance, if a carbon tax is considered to be a direct tax, then adjusting at the point of export would constitute a prohibited export subsidy.¹⁸ But if it is considered an indirect tax, then such adjustment would be legal. The GATT Working Party could not reach consensus on whole categories of taxes—including taxes on inputs to the production process, like machinery, advertising, or energy—and a carbon tax likely falls into this legal grey area.

One could argue, however, that carbon taxes are not direct taxes. Under the SCM Agreement, direct taxes are defined as “taxes on wages, profits, interests, rents, royalties, and all other forms of income, and taxes on the ownership of real property”¹⁹ and indirect taxes are defined as “sales, excise, turnover, value added, franchise, stamp, transfer, inventory and equipment taxes, border taxes *and all taxes other than direct taxes and import charges*” (emphasis added). If we accept, based on these definitions, that a carbon tax is not a direct tax, then it is an indirect tax and therefore adjustable (Maruyama 2011; Hillman 2013; Pauwelyn 2013).

Thus export adjustment may be permissible in conjunction with a carbon tax, subject to one more prohibition of the SCM agreement: If the export adjustment is in excess of the tax levied domestically, then it is clearly a prohibited export subsidy.²⁰ On the other hand, if the BCA accompanies an ETS, the legal questions are straightforward: Because there is no provision in WTO law for border rebates of regulatory costs, export rebates in the context of a BCA-ETS regime would very likely be considered prohibited export subsidies.

Guidance for Designing and Implementing BCA

The economic and legal literatures just summarized offer important insights for designing and implementing BCAs in practice. In this section, we provide guidance for implementing BCA by examining key design issues, from the objective to eligibility to determining the adjustments. We highlight the design choices that are best suited to meeting the sometimes competing objectives of environmental effectiveness (reducing carbon leakage) and consistency with international legal obligations, as well as administrative feasibility.²¹ For each issue, we also highlight research gaps.

The Objective

Policymakers may have different objectives for implementing BCA: primary among them, preventing carbon leakage, maintaining industrial competitiveness, and/or encouraging other countries to adopt policies to reduce GHG emissions.²² As discussed in the legal context section, any BCA regime would likely have to justify itself under GATT’s General Exceptions

¹⁸See SCM Annex I: Illustrative List of Export Subsidies, item (e).

¹⁹Ibid., fn. 58.

²⁰Ibid., item (g).

²¹Moore (2011) also includes a political feasibility condition, that domestic and foreign firms support (or do not object to) the combined climate and BCA policy.

²²For example, the U.S. Climate Leadership Council proposal aims to use BCA to “protect American competitiveness and punish free-riding by other nations, encouraging them to adopt carbon pricing of their own” (Baker et al. 2017).

provisions, and the grounds for such an exception do *not* include preserving competitiveness, even if addressing competitiveness could smooth the way for more stringent climate policy.

The economic literature has explored with interest using trade sanctions to enforce participation in a carbon pricing coalition (e.g., [Lessman, Marschinski, and Edenhofer 2009](#); [Irfanoglu, Sesmero, and Golub 2015](#); [Nordhaus 2015](#)). However, this leverage objective also faces legal problems. Sanctions in excess of domestic carbon payments would be seen as discrimination. But the effectiveness of BCA in enforcing compliance may be limited; export streams represent a fraction of total country-level production within EITE sectors, and an even smaller share of the broader economy, which means the costs to exporters are unlikely to outweigh their costs of joining a carbon pricing regime ([Weitzel, Hübler, and Peterson 2012](#)). Rather than complying, targeted countries may prefer to retaliate against BCA with counter-vailing tariffs. However, major EITE producers such as China and Russia may have sufficient incentive to adopt abatement targets, thus reducing the global cost of climate policies ([Böhringer, Carbone and Rutherford 2016](#)).

While BCA can legitimately take aim at producer practices, using BCA to encourage adoption of specific measures (like cap and trade) at the national level or climate policy cooperation at the international level would undoubtedly conflict with CBDR. Such leverage would likely constitute arbitrary discrimination under GATT's exceptions provisions because measures tied to country-level policies will punish all producers from targeted countries, regardless of their individual environmental performance. Furthermore, BCA is sufficiently divisive as to risk hindering efforts to achieve multilateral climate cooperation, particularly if wielded as leverage.²³ Thus the only objective for BCA that is consistent with WTO rules is reducing carbon emissions.

Policies Eligible for Adjustment

Fundamentally, BCA requires importers to pay for the carbon *embodied* in their products, that is, the emissions associated with their production. Abatement may reduce these emissions, but abatement costs are not adjustable. The only domestic policies that offer “like” treatment of domestic and imported products are price-based climate policies. Such policies require payments for embodied emissions and offer a clear carbon price on which to base the adjustments. Non-price-based policies may encourage abatement, but they do not require that producers pay for the remaining embodied carbon. Therefore BCA cannot be used in conjunction with performance standards or other nonprice regulations.²⁴

Products Eligible for Adjustment

Which sectors should have their products border adjusted? Economic studies generally examine either comprehensive BCA (applied to all products and supply chains) or BCA aimed

²³The intense controversy surrounding the EU's aviation emissions levy testifies to that, as do a number of WTO disputes over unilateral extrajurisdictional action.

²⁴To illustrate, performance standards may set a maximum emissions intensity, but they do not charge for all emissions. Such standards are a less efficient version of tradable performance standards, which implicitly combine a price on emissions with a subsidy to output that is equal to the value of the per-unit emissions allocation. The subsidy on average negates the embodied emissions charge, so nothing remains to be adjusted, especially since like treatment requires that any subsidies afforded domestic products must also be offered to imports.

only at EITE sectors. No studies have addressed the issue of where, precisely, to draw the line for eligibility. In practice, most BCA proposals have focused on energy-intensive sectors (e.g., the American Clean Energy and Security Act, allocation approaches in California and the EU), although broader coverage has advocates in certain policy circles (Baker et al. 2017).

Several factors suggest that narrow coverage is best. First, the chances of meeting GATT's exceptions requirements are jeopardized if a BCA's protection for domestic sectors goes beyond what can be justified by environmental objectives. Second, studies show that the majority of leakage mitigation benefits are obtained when BCA is applied only to the major EITE sectors (Böhringer, Carbone, and Rutherford 2012). Moreover, the administrative costs of applying BCA to sectors with low leakage risk are large relative to the carbon reduction benefits, and including goods with long, complex supply chains makes preventing transshipment difficult (discussed later). Finally, a broad application of BCA to all products and all embodied emissions shifts the burden of climate policies even more toward developing countries, without greatly improving (and possibly even decreasing) cost-effectiveness (Böhringer, Carbone, and Rutherford 2018), which runs counter to CBDR.

Narrow coverage requires identifying the sectors (and hence products) that are at the greatest risk of leakage. Eligibility should rest on a combination of two criteria: carbon exposure and trade exposure. First, would the carbon price substantially raise production costs in the sector? Ideally, such cost exposure would be calculated as the CO₂ intensity (e.g., tons of GHG emitted by the sector per unit of value added) multiplied by the projected emissions tax or allowance price. Second, would trade competition impede the ability to pass those cost increases on to consumers and cause substitution to unregulated products? Trade intensity—measured as the value of imports and exports in the sector relative to total production plus imports—is a commonly used but imperfect proxy for trade sensitivity. In practice, variants of these criteria have been used to justify preferential treatment. The American Clean Energy and Security Act used thresholds of 5 percent energy or CO₂ intensive (energy costs generally being a weaker hurdle) and 15 percent trade intensive. By way of comparison, phase 3 of the EU ETS used less stringent criteria for free allowance allocation, essentially allowing coverage of firms that were trade exposed without also being GHG intensive, with a resulting 175 products designated vulnerable to leakage.²⁵ California uses similar metrics but assigns different levels of leakage risk, phasing out allocation more quickly for lower levels; they identified 16 sectors as high risk (trade intensity greater than 19 percent), 13 as medium, and 3 as low (trade intensity less than 10 percent).²⁶ The EU is taking a similar approach in phase 4, reducing the carbon leakage list to about 50 sectors.²⁷

²⁵2014/746/EU: Commission Decision of 27 October 2014 determining, pursuant to Directive 2003/87/EC of the European Parliament and of the Council, a list of sectors and subsectors which are deemed to be exposed to a significant risk of carbon leakage, for the period 2015 to 2019.

²⁶See Table 8-1 of Cap-and-Trade Regulation 95870(a). <https://www.arb.ca.gov/cc/capandtrade/finalreg-order.pdf>.

²⁷https://ec.europa.eu/clima/policies/ets/revision_en.

Because rent-seeking firms will try to ensure their BCA eligibility, the criteria for selecting eligible products must be fixed and transparent. The appropriateness of the common criteria for evaluating leakage remains an important research gap (Fowlie and Reguant 2018). For example, the trade literature offers methods for estimating trade sensitivities (elasticities) (Hillberry and Hummels 2013), but such estimates are rarely calculated at the level of disaggregation needed for policy analysis. Fischer and Fox (2018) do so and find significant differences in import sensitivity among EITE subsectors compared with their aggregates. Fowlie and Reguant (2018) find similar estimates for imports but higher estimates for exports. Sato et al. (2015) assess the performance of leakage indicators for UK and German firms and find that carbon intensity (relative to gross value added) is a robust metric, but that within-sector heterogeneity makes the trade intensity criterion a poor measure of ability to pass through carbon costs. To assess vulnerability to carbon leakage, Martin et al. (2014) combine managerial interviews with economic performance data and find that most EU ETS sectors are overcompensated, suggesting that policymakers overestimate leakage. Fowlie, Reguant, and Ryan (2016) undertake a first attempt to compare econometric estimates of leakage rates with trade and energy intensity indicators and conclude that leakage risk increases with both in combination; that is, sectors with high energy intensity but low trade intensity exhibit low leakage risk.

In sum, the literature highlights the importance of requiring sectors to meet criteria for *both* trade and carbon exposure. Initial findings provide some support for using the simple trade intensity proxy rather than, say, empirical estimates of trade sensitivity, which are difficult to standardize (Fowlie, Reguant, and Ryan 2016; Fischer and Fox 2018). Finally, given the low carbon prices in most markets, and that even carbon-intensive industries do not face significant leakage risk if carbon prices are low, the measure of carbon exposure should be more than simply carbon or energy intensity, rather it should be an appropriate *cost exposure* threshold. Future research could help identify where those thresholds lie.

Embodied Emissions

Once a product is deemed eligible for BCA, a methodology is needed for calculating its emissions content. The *system boundary* defines what emissions in the product's life cycle are included in the BCA calculation. We identify three categories or "scopes" of emissions.²⁸ Which ones should be included inside the system boundary depends on how significant the inclusion of those GHG emissions would be, whether the GHG emissions are already accounted for within another sector, and the feasibility of collecting robust data. We then consider methods for measuring emissions within those scopes.

Scope 1 emissions are *direct emissions* from a given product's production process. Scope 2 emissions are *indirect emissions associated with energy use* (electricity, steam or heat generated offsite and purchased). Such emissions can represent the majority of emissions from processes such as metal smelting, and a significant share of total GHG emissions from sectors like steel and cement. Scope 3 emissions are any *indirect production-related emissions* that are not covered by scope 2, such as emissions that are embodied in inputs (like steel in machines) or

²⁸The definitions of scope 1, 2, and 3 emissions here are taken directly from the GHG Protocol. See www.ghgprotocol.org.

even downstream activities like transportation or waste disposal. Calculating these emissions is complex (particularly for imports), requiring data that often is not readily available, and could suffer from problems of double counting or the inclusion of emissions not covered in the domestic scheme (e.g., the EU ETS does not cover entire supply chains).

Scope 1 emissions are always included in the system boundary. Due to their complexity and relatively small share of emissions for EITE industries, scope 3 emissions are best excluded from the system boundary. There is no consensus on the extent to which manufacturers should be responsible for reducing these supply-chain emissions. The leakage associated with pricing scope 2 emissions, however, can warrant covering them under a BCA regime and thus including them in the system boundary (Bednar-Friedl, Schinko, and Steininger 2012). To avoid violating GATT's national treatment principle, any emissions not covered in the domestic regulation must not be included in the system boundary for BCA.

Once the system boundary is set, *benchmark emissions* (i.e., measured or default emissions content) must be determined for each scope that is included. Such an exercise may have already been conducted for domestic sources for the allocation of emission allowances. However, BCA requires a determination for foreign sources. Should actual emissions data or a sectorwide benchmark be used? This decision involves trade-offs between firm incentives, industry incentives, gathering data, compliance costs, and WTO obligations. To date, the economics literature offers little guidance concerning this decision. Exporting firms have an incentive to decrease their emissions only if doing so lowers their BCA payments, that is, if actual emissions are used to calculate the adjustment. On the other hand, using firm-specific data opens the possibility of reshuffling emissions, that is, the market could simply reallocate the lowest-carbon production for export to carbon-regulating countries while higher-carbon production remains for unregulated consumption. This trade-off needs further attention in the literature. Collecting credible firm-level data is costly and requires third-party verification; mandating that foreign producers bear these costs could be considered an unacceptable trade barrier. For these reasons, default sector-based benchmark emissions must be used. However, allowing producers to provide third-party-verified firm-level data on emissions intensity (and using the same system boundaries that are used for implementing country producers) would improve the odds of a BCA scheme being found legal under GATT's exceptions provisions.

In setting the emissions benchmark, three choices must be made. The first concerns the benchmark *level*. A high benchmark—such as worst available technology—risks appearing punitive and involves the trade-offs of using firm-specific data (discussed earlier). A low benchmark—such as best available technology or average emissions of a clean importer—may require no foreign data, but it provides little incentive for improvement and less protection against leakage.

The second choice concerns the *number* of benchmarks to set for a given product. As noted earlier, international trade law considers identical commodities that are produced in different ways as “like,” which means they require similar treatment (i.e., a single benchmark). However, some products have multiple production processes with different emissions intensities (e.g., steel can be made from iron ore using a blast furnace or from scrap steel using an electric arc furnace), suggesting that multiple benchmarks may be appropriate.

The third choice is whether the benchmark should *differentiate* among exporters based on country-specific variables. Data for exporting countries may not be readily available or verifiable, and gathering such data may be an arduous task. Moreover, country-specific

benchmarks may conflict with GATT's MFN provisions and would require provisions to prevent transshipment from countries assigned higher-intensity benchmarks.²⁹

Uniform benchmarks, such as those based on importing country characteristics, are simple to calculate and avoid problems of discrimination, but they are less able to accurately reflect the actual emissions intensity. A hybrid benchmark—using a uniform benchmark (such as average implementing country practice) for scope 1 emissions and a country-specific benchmark for scope 2 emissions—could balance the trade-offs between accuracy, incentives, and legal issues. Such a system is effective at preventing leakage because it allows the more stringent benchmark to focus only on the scope with the most potential for regional variation (scope 2). Meanwhile, it avoids the data challenges of firm-specific scope 1 emissions, which generally have less variation, since production processes are fairly similar across countries ([International Energy Agency 2007](#)). A hybrid scheme of this type would still face GATT MFN problems, but the hybrid benchmark's use of country-specific estimates for scope 2 emissions has a legitimate environmental rationale, which is important for a GATT exception. Otherwise it may be difficult to differentiate adjustment levels based on the country of origin rather than doing so at the level of individual producers based on their environmental performance.³⁰

Compatibility with WTO rules may also be enhanced by adhering to international standards and protocols where available, both for data submission and benchmark creation. For example, [Cohen and Vandenberg \(2012\)](#) argue that international standards that emerge informally through voluntary carbon footprint labeling might form a basis for formal procedures to determine emissions benchmarks. Avoiding duplicative exercises can also reduce compliance costs. Finally, to counter the negative impact of the compliance costs associated with an involuntary scheme, implementing states should offer support—in the form of financial and technical assistance for accounting, reporting, and verification—to assist foreign covered exporters in submitting verified individual data.

Nevertheless, the economic trade-offs among the various emissions calculations merit further study. In particular, carbon leakage models to date have largely ignored within-sector emissions heterogeneity, making it difficult to estimate the potential for emissions reshuffling versus reductions driven by more firm-specific measures.

The Adjustment Price

After determining the embodied emissions calculation, one must then establish a carbon price and compliance method for the BCA. If firms in the implementing country are regulated with a carbon tax, that should be the basis for the price charged to the exporting country's firms. If the implementing country uses cap and trade, importers could be required to

²⁹Special benchmarks could be developed for LDCs in order to respect the principle of CBDR. The importing country could assume, for example, that all imports from LDCs have used best available technology. However, this modification has no environmental rationale, and would thus likely fail the GATT exception tests.

³⁰In *US – Shrimp*, because the regulations certified imports on a country-by-country basis rather than a producer-by-producer basis, the import ban was ultimately applied to fishers that may have actually used the required equipment. The appellate body ruled that this showed a disconnect between the measure and the environmental objective. In the same vein, it may be illegal to assign foreign producers benchmark values for GHG intensity if domestic producers are allowed to avoid a benchmark by providing actual values; foreign producers should also be allowed this opportunity (*US – Gasoline*).

purchase allowances to cover their emissions or pay a fee based on the market price of allowances. Alternatively, one could allow importers or foreign producers to purchase international carbon offsets (e.g., certified emissions reductions) up to the determined value of the adjustment. To avoid problems of unpredictable swings in price, importers should be afforded the same compliance timeframe as domestic firms, or the BCA price should be set on a regular and infrequent basis (e.g., annually, based on a rolling average of previous periods of measurement). In sum, the BCA price and compliance mechanism should adhere as closely as possible to the terms faced by domestic firms. Any unfavorable treatment of foreign firms risks violating GATT's national treatment provisions and could only be upheld under GATT's exception provisions.

Other Foreign and Domestic Policy Measures

In order to ensure comparable treatment, BCA design must also account for carbon payments made by foreign firms in their home countries. Not granting such credit to foreign firms would likely lead to a finding that the BCA regime is arbitrary in its application and not primarily aimed at environmental objectives, and thus in violation of GATT's exception provisions. Ideally the BCA would offset the *differential* between foreign and domestic price-based climate policies.³¹ Of course, if the foreign system has a different compliance mechanism or system boundary than the domestic system, this adjustment may require more than simply calculating the difference in carbon tax rates.

A BCA system must also recognize any free allowances or other compensatory mechanisms enjoyed by domestic firms and offer comparable benefits to imports covered by the BCA. In some cases, the BCA level may need to be adjusted down to zero. Generally BCA should not be combined with other cost compensation behind the border (i.e., applied to domestic products) because such compensation would undermine the case for a GATT exception. For symmetry, adjustment for foreign carbon prices must account for free allocation abroad.

Exemptions

An alternative to adjusting the BCA based on country-specific factors is the provision of a wholesale exemption, which is equivalent to modifying the emissions benchmark to zero. Exemptions based on a measure of climate action by the trading partner are commonly considered for a BCA regime. Note that such measures risk being viewed as attempts to exert leverage over trading partners, which is inconsistent with the legally acceptable objectives under GATT (discussed earlier). Indeed, case law suggests that it may be illegal to demand specific policies as a basis for exemption from BCA rather than requiring that the exporter achieve some given level of climate performance.³² Country-based exemptions also have the potential to unfairly discriminate among exporters and may thus be incompatible with the GATT's MFN requirements. Nevertheless, the exemption might be justified under GATT's exception provisions if it contributes to protecting the environment.

³¹For the same reasons that BCA should not be allowed for sectors or products that are regulated with non-price-based policies, such policies in the foreign country should not generate adjustments to the BCA.

³²The appellate body in *US – Shrimp* ruled against the U.S. law for demanding that foreign shrimp fishers use exactly the same equipment as U.S. fishers to avoid the incidental capture of turtles.

We consider five possible exemptions:

1. *Exempting countries that implement a national emissions cap.* An effective national cap theoretically precludes leakage (even if emissions rise in EITE sectors). This exemption would likely be allowed under GATT's exception requirements because of the strong relationship between the defining national characteristic (an emissions cap) and the environmental objective (preventing leakage). However, many emissions caps are not strict, thus allowing for leakage (e.g., use of overcredited offsets for compliance, low price ceilings, caps that are not economy-wide, or lack of enforcement).
2. *Exempting countries that take "adequate" national actions other than national caps.* This exemption faces the challenge of defining *ex ante* what constitutes "adequate" action. For price-based mechanisms, exemptions are a much blunter instrument than adjusting for a carbon tax or allowance price in the calculation of the BCA. We have also argued that non-price-based mechanisms should not be eligible for border adjustment because their cost burdens are nontransparent and embodied emissions remain unpriced, therefore the case for exempting them is unclear. In any case, any national climate regime other than a hard cap is susceptible to leakage.
 On the other hand, when the implementing country is party to a multilateral agreement on climate change—which could be interpreted as international recognition of "adequate" national actions—not using this exemption may violate GATT's exception provisions concerning arbitrary treatment of exporting countries. However, this is a grey area because the Paris Agreement relies on NDCs rather than negotiated targets, and thus it could be argued that there is no clear consensus on "adequacy" of national actions.
3. *Exempting sectors from countries that implement a sectoral cap.* If a country effectively caps a given sector's emissions, no sector-level leakage will occur. This exemption probably faces no trade law issues concerning MFN because the discrimination is based on sector (not country) characteristics. Adjustments for sectoral carbon pricing (or export taxes) could also be included in the BCA calculations.
4. *Exempting least developed countries and low-income countries.* An exemption for least developed countries and low-income countries would help the measure align with the UNFCCC principle of CBDR and the WTO principle of special and differential treatment. However, very few of these countries export the type of EITE goods targeted by BCA. Moreover, this exemption creates problems with MFN treatment, which exempts only tariff treatment intended to aid development in the target countries.
5. *Exempting countries by means of administrative flexibility.* For example, exempting countries that have very minor (i.e., de minimus) trade in covered goods could lower administrative costs. Other, broader public policy objectives might motivate exemptions. However, such exemptions would conflict with the GATT's MFN provisions and may lack the predictability that should be the hallmark of any scheme.

Given these considerations, exemptions should be incorporated into a BCA regime with caution. They may be useful if they are administratively simpler mechanisms than BCA modifications for avoiding double charging (e.g., where covered sectors operate under a credible hard emissions cap in the exporting country, or where carbon prices are harmonized) or for aligning with CBDR goals.

It is also important to note that any differentiation based on the country of origin raises transshipment problems. Strong provisions would be required to ensure that any products coming from the preferentially treated country have undergone a substantial transformation there. Otherwise, countries facing high adjustments could ship products to low-adjustment or exempted countries for reexport to avoid being covered by the BCA. Transshipment provisions work best when the goods in question are wholly obtained in a single country or at least have a very simple supply chain. This bolsters the argument made earlier for maintaining a narrow scope of coverage that precludes all but a small number of commodity-oriented EITE goods.

Export Adjustments

Until this point we have focused on designing BCA for imports. True destination-based (or consumption-based) carbon pricing would also make border adjustments for exports. Export adjustment would offer a rebate to domestically produced products that are exported, with the rebate being equivalent to the products' embodied carbon payments. Adjustment for exports would allow such products to compete on a level playing field with unregulated products in foreign markets, thus avoiding leakage from loss of market share in third-country markets. Export adjustment could also help avoid the issue of double taxation when the products are shipped to a destination country that also applies BCA to its imports.

The literature is mixed on the effectiveness of export adjustments. A meta-analysis by [Branger and Quirion \(2014b\)](#) found that export adjustment played an important role in reducing leakage. However, studies comparing the effects directly find that most of the leakage reduction from BCA can be captured by a scheme that contains only import adjustments ([Böhringer, Balistreri, and Rutherford 2012](#); [Fischer and Fox 2012b](#)). This finding holds only for countries that are heavy net importers of BCA-eligible goods.

Note that the American Clean Energy and Security Act and the 2010 French proposal for a carbon inclusion mechanism focused on adjustment for imports only, but the Climate Leadership Council carbon tax proposal includes export adjustment. In the end, practical challenges may prevail against export adjustment. As noted earlier, the legal status of BCA for exports is uncertain under WTO law. Moreover, BCA for exports is difficult to reconcile with an approach that carves out exemptions from import adjustment.

The Use of Revenues

The final design choice concerns the use of revenues collected from a BCA for imports. The disposition of these revenues has a substantial impact on the international distribution of a climate policy's economic effects, as well as on the perception of BCA.

Economic analyses show that when countries that implement BCA retain the revenues, more of the burden of the climate policy package shifts toward developing countries; alternatively, dedicating the revenues to benefit the exporting countries can avoid this shift or even make exporting countries better off ([Böhringer, Balistreri, and Rutherford 2012](#); [Fischer and Fox 2012a](#)).

Dedicating the revenues toward objectives that assist developing countries serves two purposes. First, it respects the principles of CBDR. Second, it demonstrates that the purpose of the BCA is to avoid leakage and not to provide protection for domestic producers. For

example, revenues could be refunded to the exporting country directly or via clean technology transfer. The implementing country could earmark the revenues to internationally administered funds for climate change mitigation and/or adaptation or disburse them for mitigation and adaptation projects. Any of these options would likely improve a BCA regime's chance of success in meeting GATT's exception requirements by helping to demonstrate the BCA's environmental objectives.

Ensuring that the revenues are not retained by the importing country also removes domestic incentives to manipulate the terms of the adjustment in order to enhance national welfare in a beggar-thy-neighbor fashion. For all these reasons, BCA proceeds should not be dedicated to general revenues in the implementing country. For jurisdictions that discourage or prohibit earmarking of tax revenues to specific purposes, a package of foreign assistance measures together with the BCA could help demonstrate good faith.

Summary and Conclusions

Placing carbon pricing at the center of climate policy is widely accepted to be the most cost-effective way to reduce GHG emissions. The effectiveness of carbon pricing, however, can be undermined by international trade: goods, capital, and energy flow across markets that have different climate policies, which can lead to carbon leakage. Addressing carbon leakage can thus make national climate policy more effective. Among the unilateral options to address leakage, BCA may be the most efficient, but also the most controversial and legally challenging.

This article has highlighted best practices in the design and implementation of BCA, based on interdisciplinary research to date. Another purpose of this article has been to warn policymakers considering BCA about just how difficult it is to get it right. Several elements of the design described here—for example, the setting of product benchmarks—are long-term, complex, and administratively costly undertakings, and numerous interests will lobby for access to and influence over the process. While not deciding arguments, these considerations need to be part of the deliberation when policymakers weigh BCA against other options for addressing leakage.

We have shown here that many of the most important welfare effects of BCA, both domestically and for trade partners, inherently depend on assumptions about specific design choices, which could influence conclusions about the costs and benefits of BCA. Nevertheless, important research gaps remain regarding many of the practical and legal issues associated with BCA. Research priorities should include, for example, a more rigorous examination of the heterogeneities within industries that are relevant for measuring emissions intensity and assessing benchmarks and impacts. Another research priority is developing better measures of leakage risk. In addition, most CGE models lack the capacity to assess the substitutability of nonenergy inputs, which is an important margin for reducing the consumption of carbon-intensive commodities—and for setting the policy scope. More rigorous research in these areas would also be helpful for the design of behind-the-border options for addressing leakage.

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